University Of California, Berkeley
Department of Electrical Engineering and Computer Sciences
Department of Mechanical Engineering

EECS C128 / ME C134 FEEDBACK CONTROL SYSTEMS (4 units)

Undergraduate Technical Elective Course

Syllabus

CATALOG DESCRIPTION

Analysis and synthesis of linear feedback control systems in transform and time domains. Control system design by root locus, frequency response, and state space methods. Applications to electro-mechanical and mechatronics systems.

COURSE PREREQUISITES

EE 16A and either ME 132 or EE 120.

TEXTBOOK(S) AND/OR OTHER REQUIRED MATERIAL

Franklin, G., Powell D., and Emani-Naeini, A., “Feedback Control of Dynamic Systems,” 6th Ed., Addison Wesley

Nise, N. S., "Control Systems Engineering," 3rd Ed., Benjamin / Cummings

COURSE OBJECTIVES

Introduce and familiarize students with dynamic systems modeling and analysis techniques that can be employed on a large variety of engineering systems. Introduce and familiarize students with control systems and design techniques including:

- Transfer function and state space models for control system analysis and synthesis.
- Root locus methods.
- Single-input single output (SISO) analysis and control methods in the frequency domain (Bode, Nyquist).
- Analysis and control using state space models. Controllability and observability. Combining state feedback with observers.

Provide students with a hands-on laboratory experience on modeling, controller design and implementation utilizing several laboratory setups including an inverted pendulum and a DC-motor positioning and velocity control system.

DESIRED COURSE OUTCOMES

Students who complete EECS128/ME134 should be able to model, analyze the response of and design control systems for many of the mechatronic devices and systems that they will encounter as professional engineers. Specifically, students that complete EECS128/ME134 should be able to: 1) Model and analyze the time dynamic response of electromechanical, and mechatronic systems systematic techniques. 2) Analyze the behavior of interconnected dynamic systems. 3) Analyze the stability and the transient and steady state response of feedback control systems. 4) Design feedback control systems using classical time and frequency domain design techniques. 5) Design feedback control systems using state space techniques. 6) Implement and tune feedback controllers on actual devices.

A key aspect of EECS128/ME134 is the inclusion of laboratory assignments, which run parallel to the lectures and homework assignments, and enhance the students' learning experience by reinforcing the learned material with realistic hands-on experiments. Students perform laboratory assignments, in which they progressively, model, identify and design controllers for a variety of experimental setups including an inverted pendulum and an industrial DC-motor setup.

TOPICS COVERED

1 Introduction to control systems.
2 The Laplace transform.
3 Mathematical modeling of electrical and mechanical systems.
4 Transfer function, poles and zeros, realizability conditions.
5 Block Diagram, Manipulation of block diagrams, open loop transfer function and closed loop transfer function.
6 Relation between state equation and transfer function, transform domain solutions of state equations, response patterns, natural frequency and damping.
7 Stability based on Routh-Hurwitz.
8 Steady state analysis of feedback control systems, steady state error to step and ramp inputs, the necessity of integral action under step disturbance, etc.
9 Root locus analysis, examples will include the analysis of PID controller and lead lag compensator based on root locus analysis.
10 Frequency response, Bode and Nyquist plots, performance specifications in the frequency domain.
11 Nyquist stability theorem, phase margin and gain margin, performance evaluation of PID controller in the frequency domain, nonminimum phase systems.
12 Lead and lag compensation and frequency domain design and loop shaping.
13 State variable theory, coordinate transformations and canonical realizations.
14 Controllability and observability, state feedback control and state estimation for single-input, single-output systems.
15 Review

LABORATORY:

Controller design, analysis and implementation on a variety of laboratory setups including an inverted pendulum, a D.C. motor positioning systems and a magnetic levitation system.

CLASS/LABORATORY SCHEDULE

Three hours of lecture and one hour of discussion per week. Three hours of laboratory per week.

CONTRIBUTION OF THE COURSE TO MEETING THE PROFESSIONAL COMPONENT

This course contributes to the students' knowledge of engineering topics and also provides realistic hands-on design experiences. Students learn how to model and analyze the responses of a variety of electrical and mechanical dynamic systems and how to design and implement controllers for these systems using frequency and time response domain input-output and state space design techniques. Theoretical concepts and design techniques are reinforced through the implementation and testing of designed control systems on realistic experimental setups in the laboratory. Students also develop modest proficiency in computer-aided tools, specifically Matlab Control System Toolbox and Simulink, both of which are used ubiquitously in the industry. Issues related to the impact of engineering solutions in an economic, environmental, and societal context are also discussed in the course. For example, it is discussed how the use of control systems can significantly enhance the performance of many electromechanical and mechatronic systems, make them cheaper and easier to built by relaxing manufacturing tolerances and improve their energy consumption efficiency.

RELATIONSHIP OF THE COURSE TO ABET PROGRAM OUTCOMES

An ability to apply knowledge of mathematics, science, and engineering. An ability to conduct experiments, as well as to analyze and interpret data. An ability to design a system, component, or process to meet desired needs. An ability to identify, formulate, and solve engineering problems. An ability to function on multi-disciplinary teams. An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

This course provides valuable theoretical and practical training in control system design and analysis of modern electrical, mechanical and devices, emphasizing a mechatronics approach to the design process. It also serves to reinforce and emphasize the connection between fundamental engineering science and practical problem solving.

Optional Elective. Counts as an EECS or ME technical elective.

ASSESSMENT OF STUDENT PROGRESS TOWARD COURSE OBJECTIVES

- Homework assignments (20%)
- Midterm examinations (20%)
- Laboratory reports (20%)
- Final examination (40%)

PERSON(S) WHO PREPARED THIS DESCRIPTION:

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April 9, 2010

ABBREVIATED TRANSCRIPT TITLE (19 SPACES MAXIMUM): Feedback Cntrl Sys
TIE CODE: LECS
GRADING: Letter
SEMESTER OFFERED: Fall
COURSES THAT WILL RESTRICT CREDIT: EECS 128 and ME 134
INSTRUCTORS: Horowitz, Tomlin
DURATION OF COURSE: 14 Weeks
EST. TOTAL NUMBER OF REQUIRED HRS OF STUDENT WORK PER WEEK: 12
IS COURSE REPEATABLE FOR CREDIT? No
CROSSLIST: Yes